Using CYGNSS to investigate relationships between wind-driven surface fluxes and tropical oceanic convection

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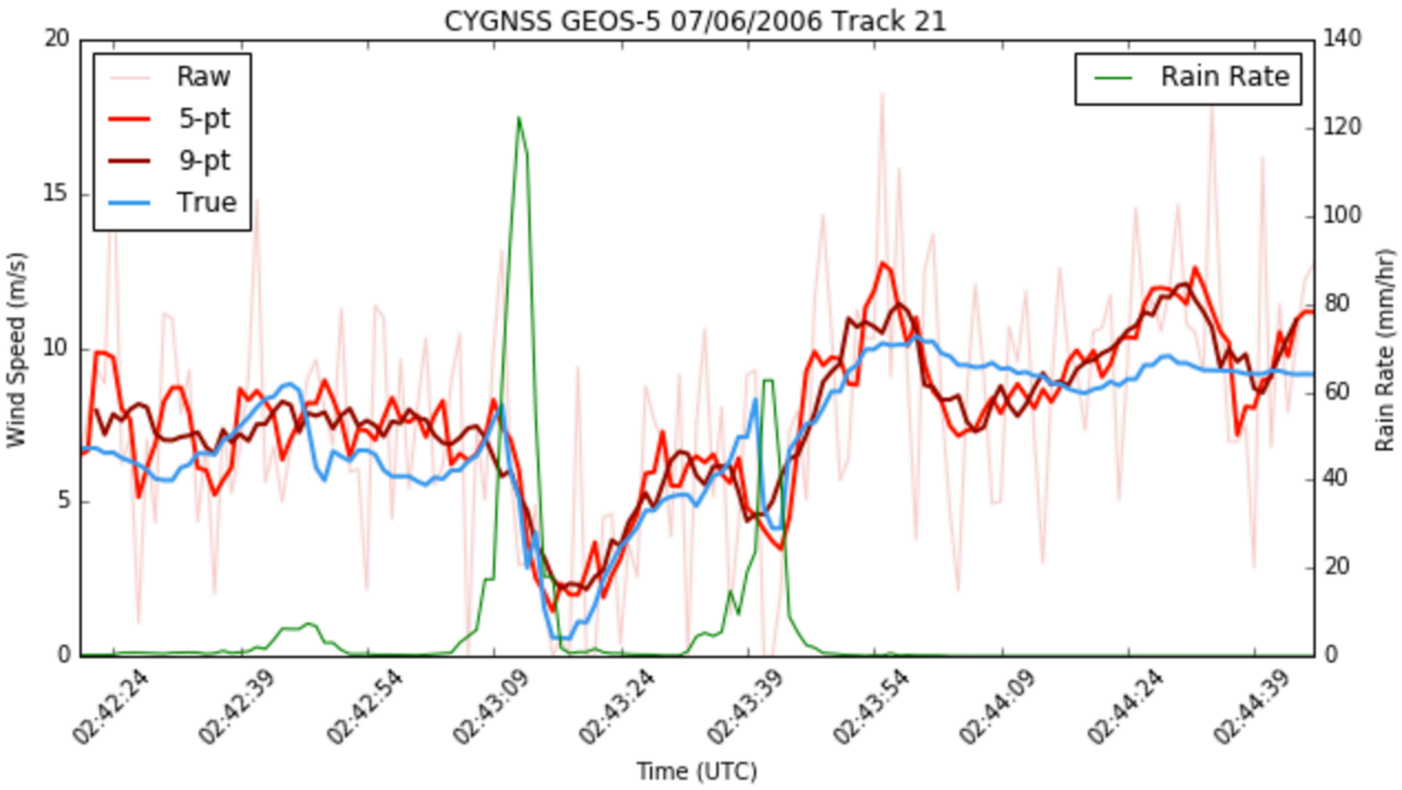
Background and Motivation

- Analyzing CYGNSS data from the perspective of individual tracks of specular points enables filtering that may enhance the accuracy of retrieved winds

- This should make CYGNSS observations easier to interpret near convective systems

- Spatial continuity of each track enables unique 1-D "cross-sections" thru tropical convection

- All-weather winds mean CYGNSS is expected to improve surface flux estimates near tropical convection



Scientific Questions

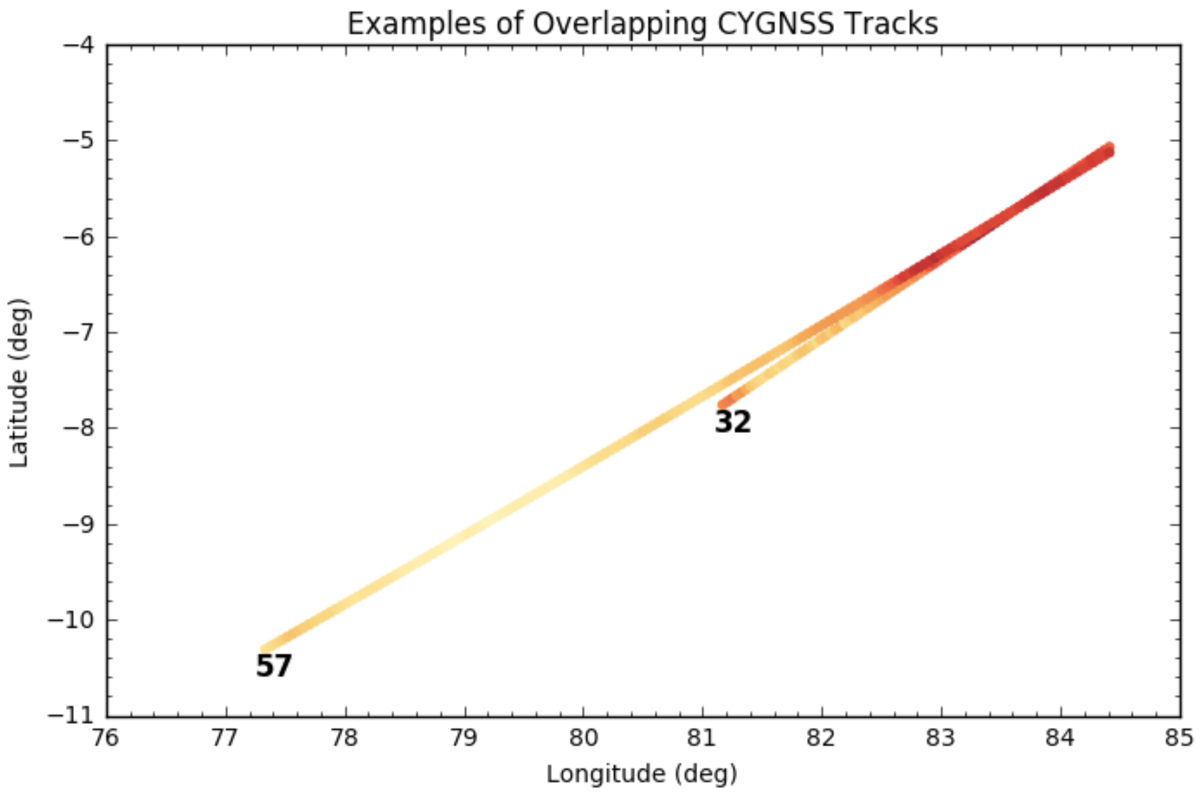
- *Do improved wind speed measurements in and near convection enable better representations of surface fluxes in observations and numerical models?*
- *How do the location/timing of wind-driven fluxes promote or inhibit convective development in MCSs?*
- *How do regional, diurnal, and intraseasonal variability in surface fluxes relate to variability in MCS behavior at these same scales?*

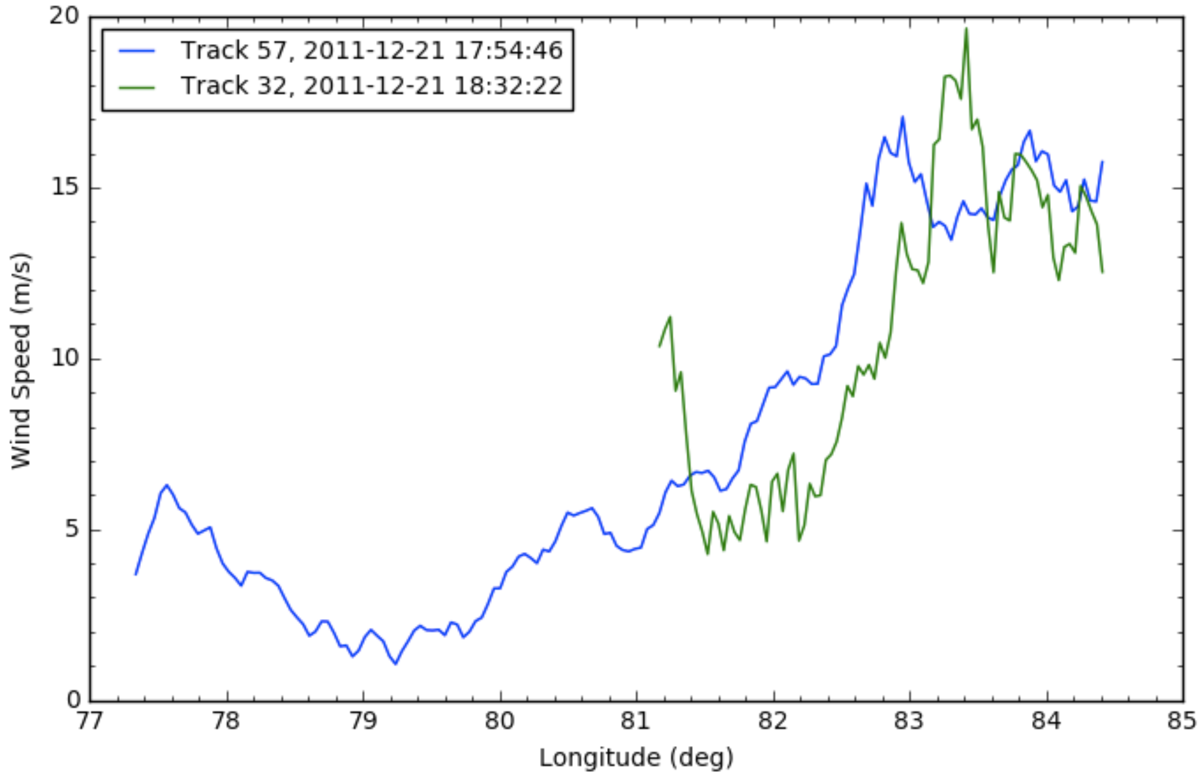
Scientific Tasks

- *Observational case studies of tropical oceanic convection featuring on-orbit CYGNSS data.*
- *Observationally based climatological analyses of tropical oceanic convection featuring up to two years (or more) of on-orbit CYGNSS data.*
- *Simulations of case studies of tropical oceanic convection featuring assimilation of on-orbit CYGNSS data.*

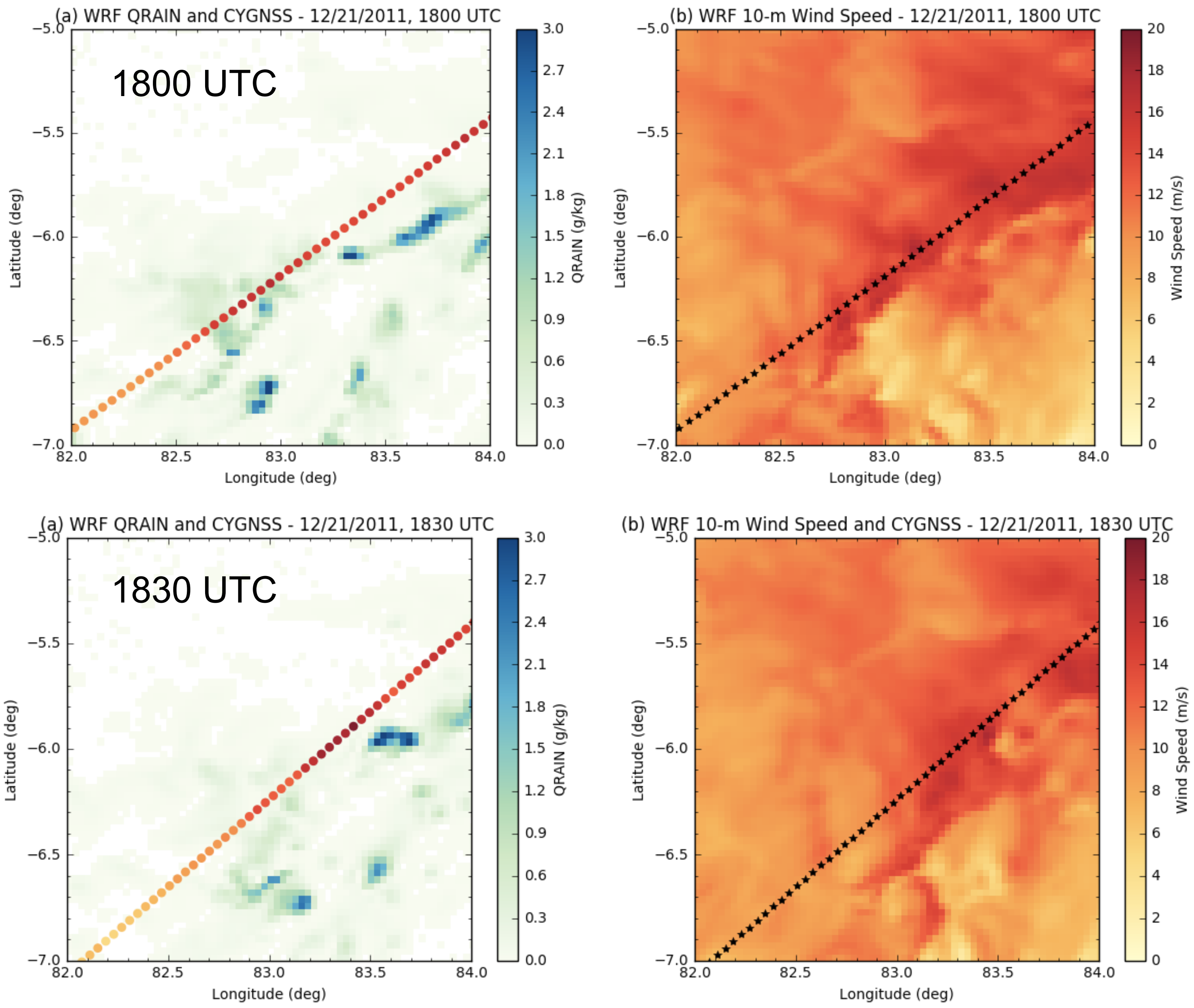
Previous work with CYGNSS End-to-End Simulator (E2ES)

Example of convective variability revealed through overlapping simulated CYGNSS tracks through MJO convection





Simulated CYGNSS observes passage of gust front between overpasses ~30-40 min apart



Turbulent Heat Fluxes

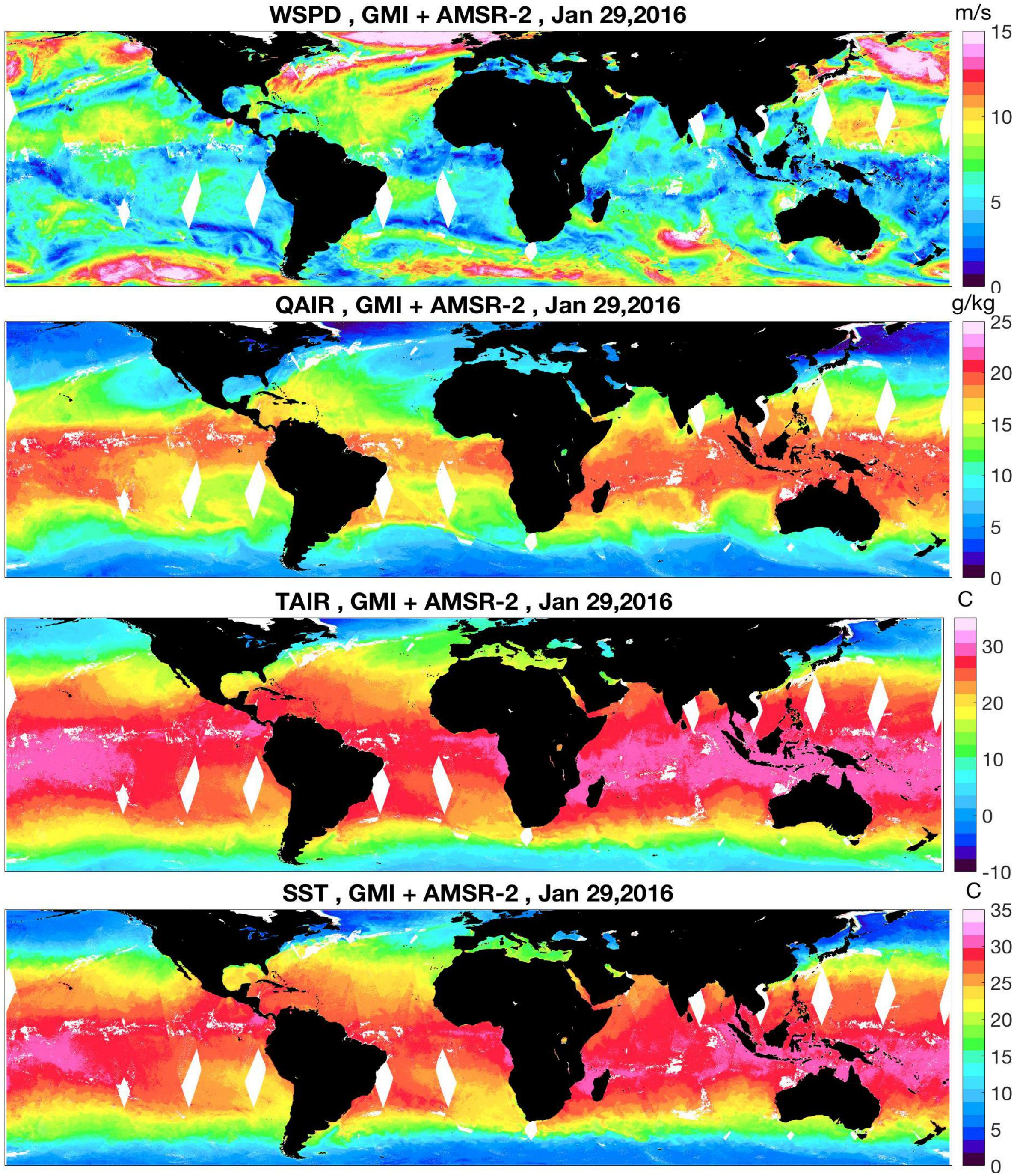
$$LHF = \rho L_v C_e (Q_s(SST) - Q_{air})(Wspd)$$
$$SHF = \rho C_p C_h (SST - T_{air})(Wspd)$$

Near-surface geophysical retrievals from intercalibrated L1C GPM IMERG TBs are being ingested into well-established bulk formulas (COARE v3.5) as part of a project to produce a near-realtime global surface flux dataset.

CYGNSS winds can be used for W_{spd} in all weather conditions

A model-based interpolation scheme for T_{air} and Q_{air} (retrieved via a neural network algorithm) can be used to fill in missing data near heavy rain

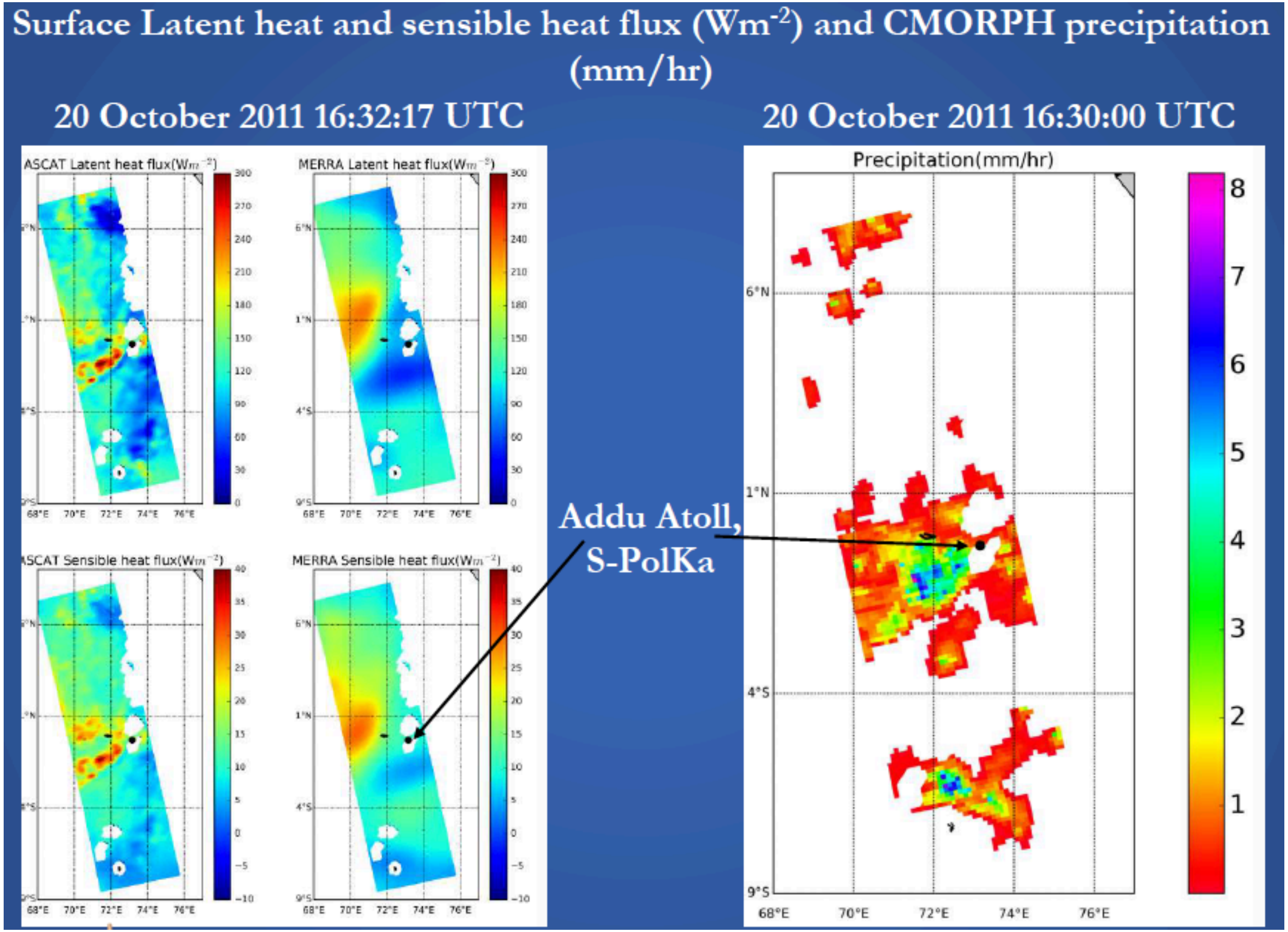
Collaboration with Derek Posselt and Juan Crespo to assist with the future production of a CYGNSS surface flux dataset



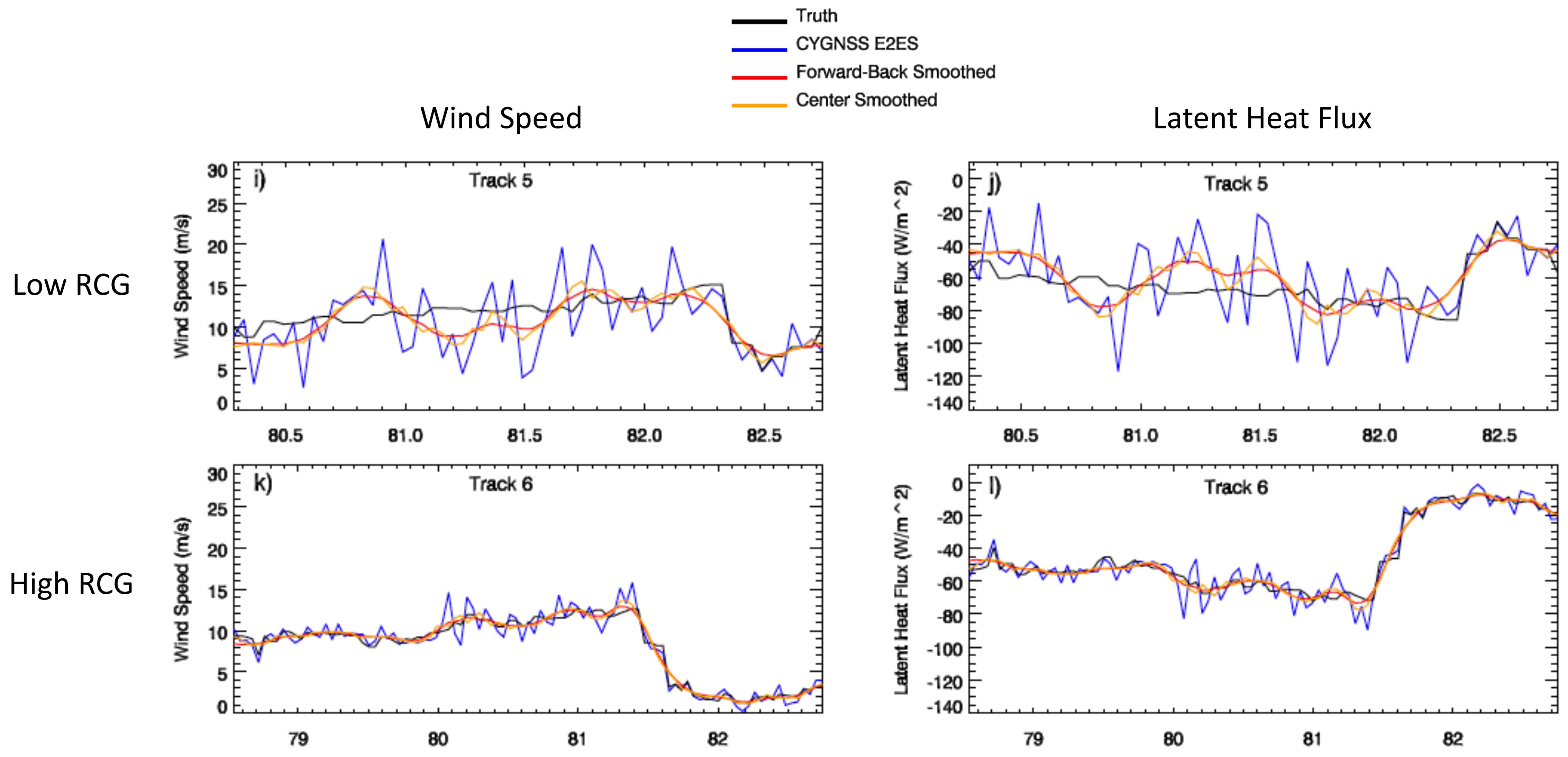
Previous Work with ASCAT

ASCAT is capable of detecting convectively driven gust fronts and cold pools, and these indicate significant differences from MERRA latent and sensible heat fluxes

CYGNSS should be able to improve wind retrievals near convection



Garg et al. (2017)

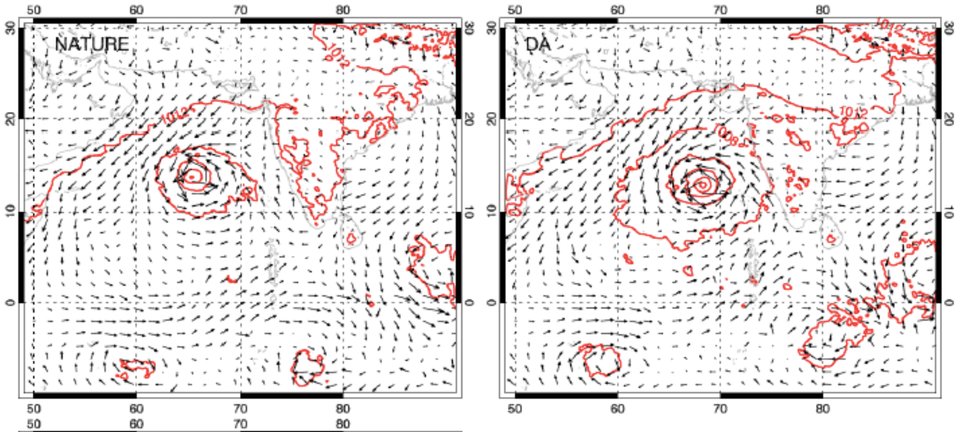


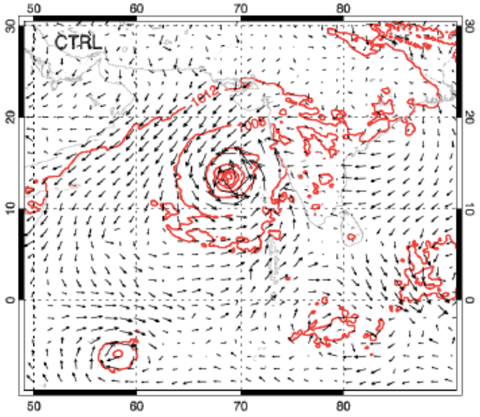
- Along-track filtering important, especially in low Range-Corrected Gain (RCG) situations

Application to Modeling of Organized Tropical Convection

- DYNAMO tropical storm that did not develop further during an MJO onset
- CYGNSS Data Assimilation helped the model to resist the tendency of the Control Run to further strengthen the storm
- Storm track position was significantly improved over the Control

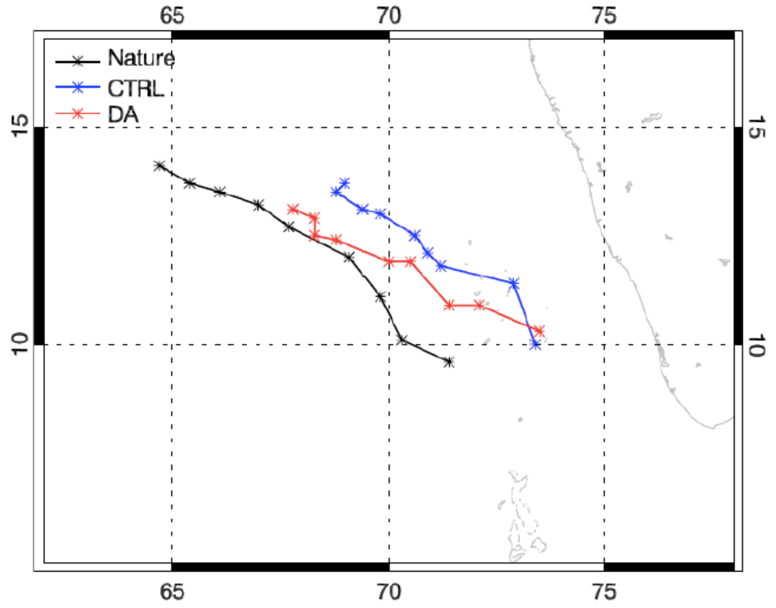
Forecast: SLP and wind vector at 18 UTC 2011-11-28



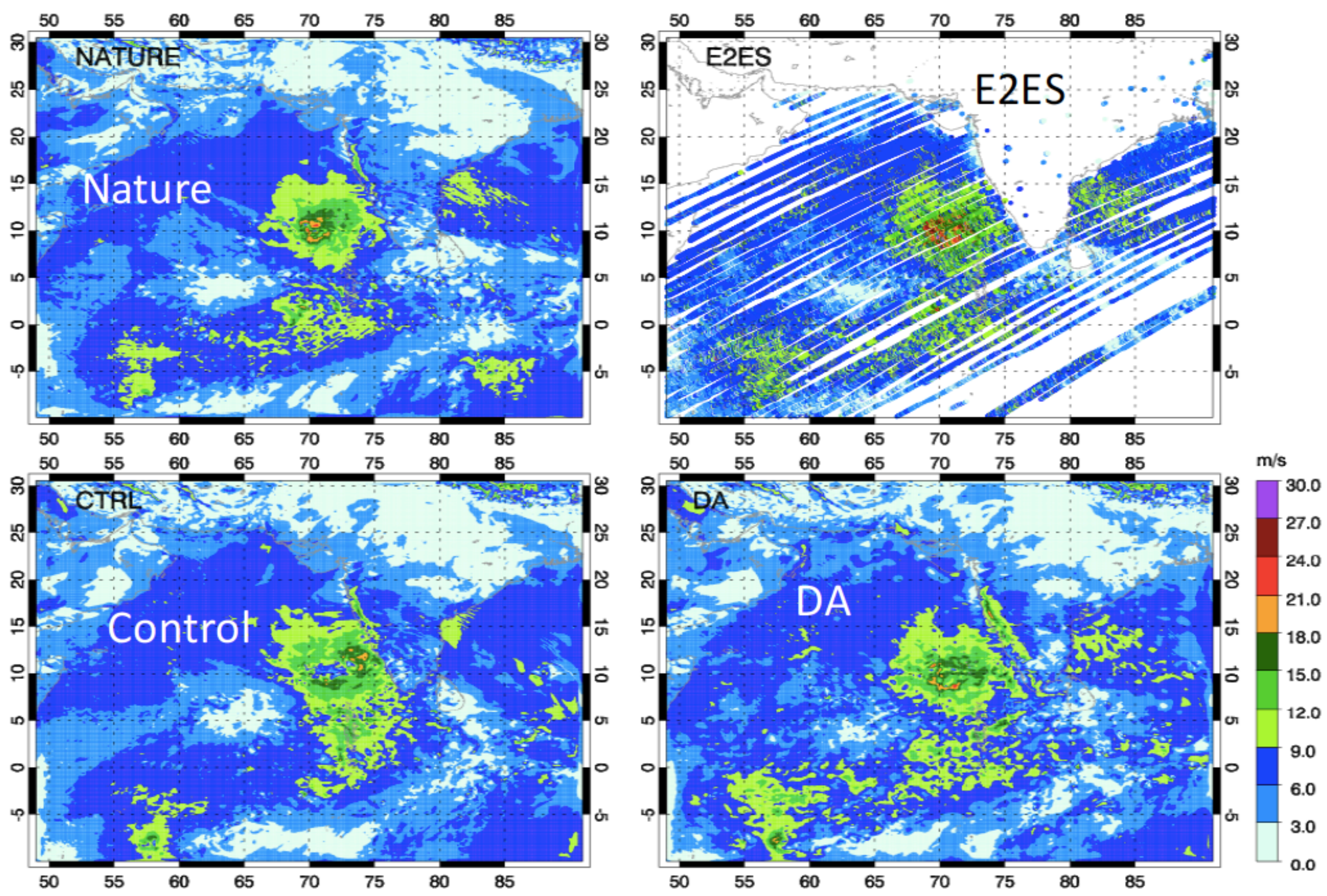


	NAT	DA	CTRL
Min SLP (hPa)	996	990	985
Max WSPD (m/s)	23.9	23.9	32.8

Storm Track
00 UTC 2011-11-27 to 00 UTC 2011-11-29

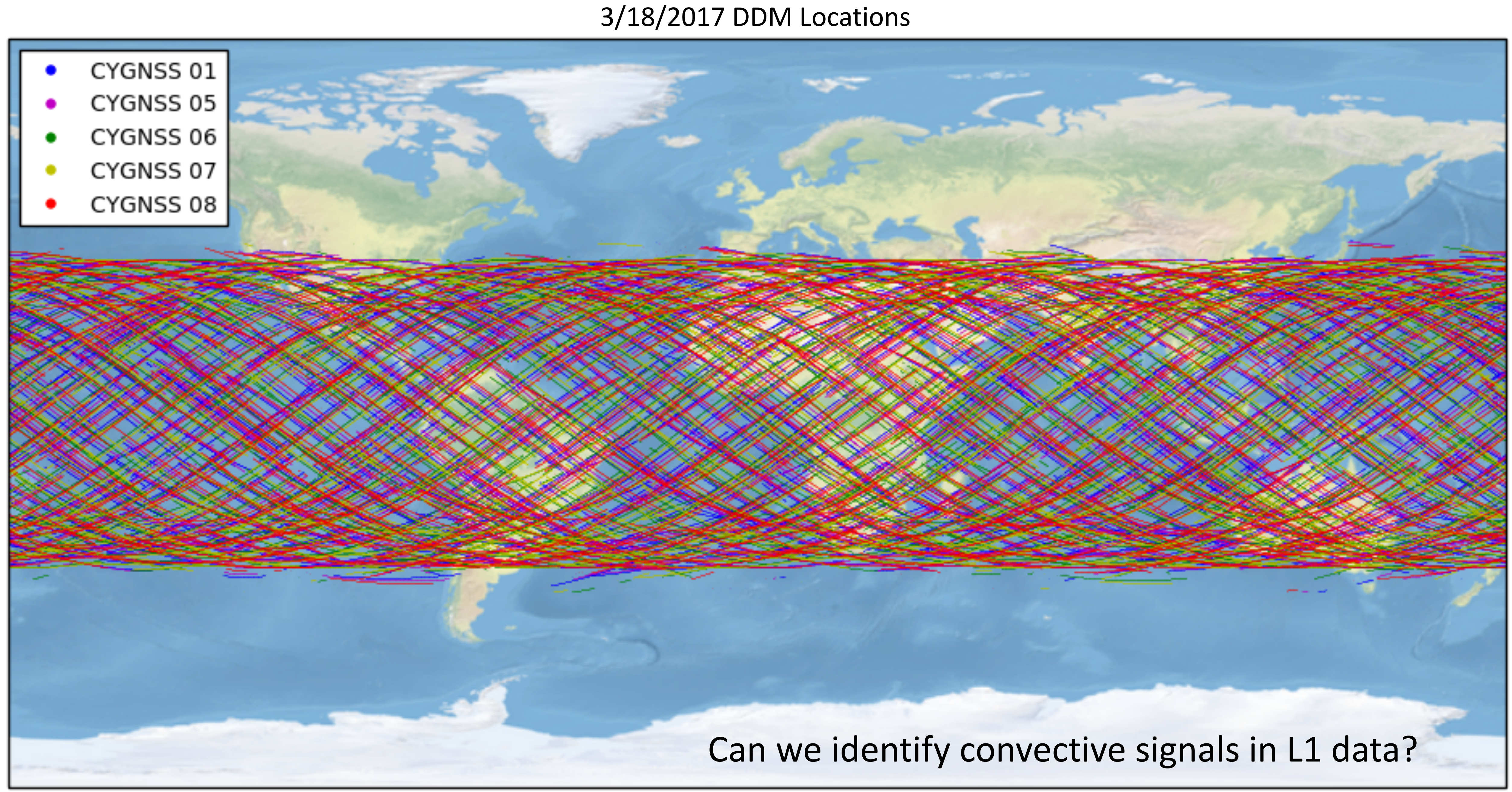


10-m Wind Speed at 0500 UTC 2011-11-27

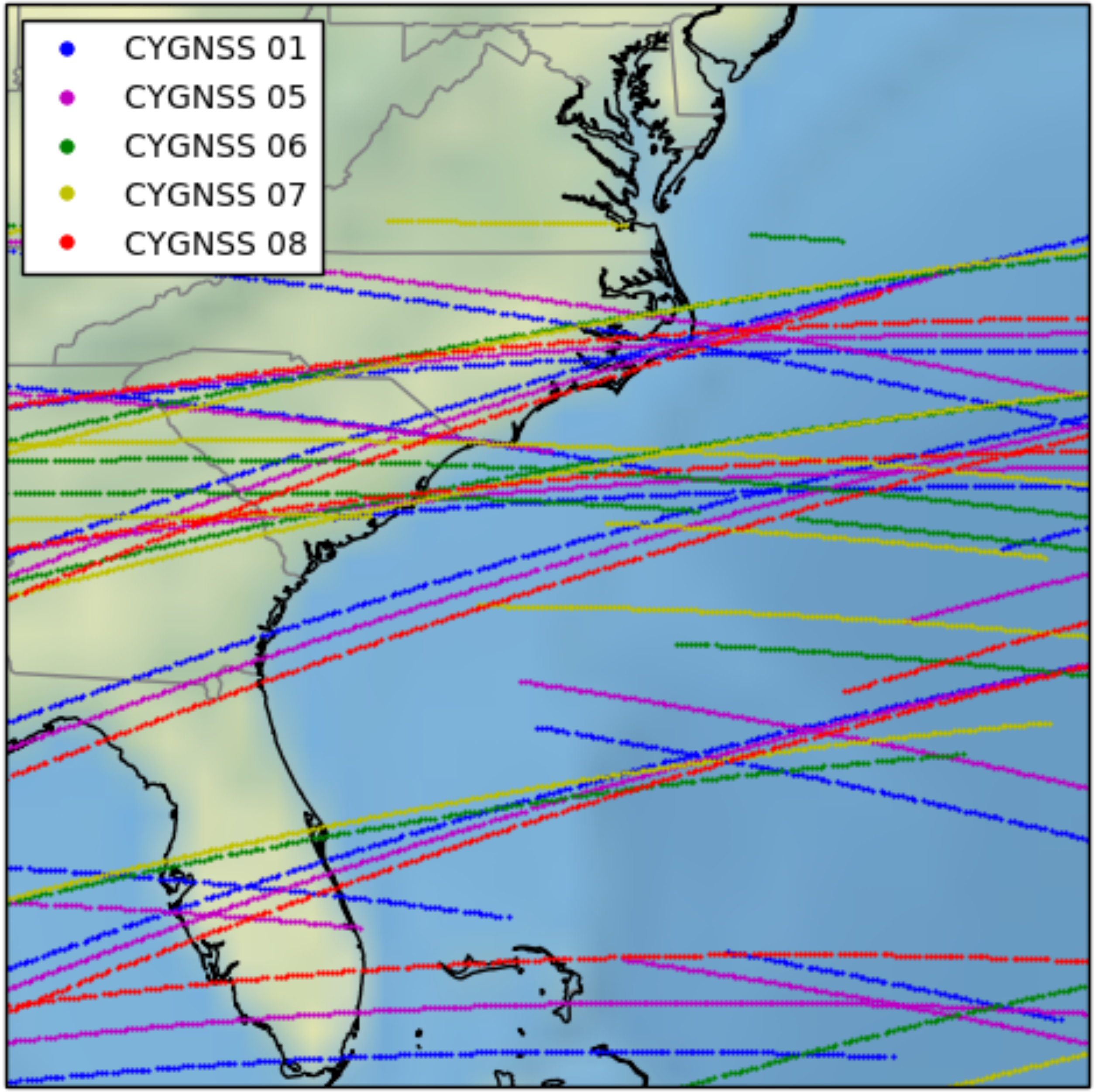


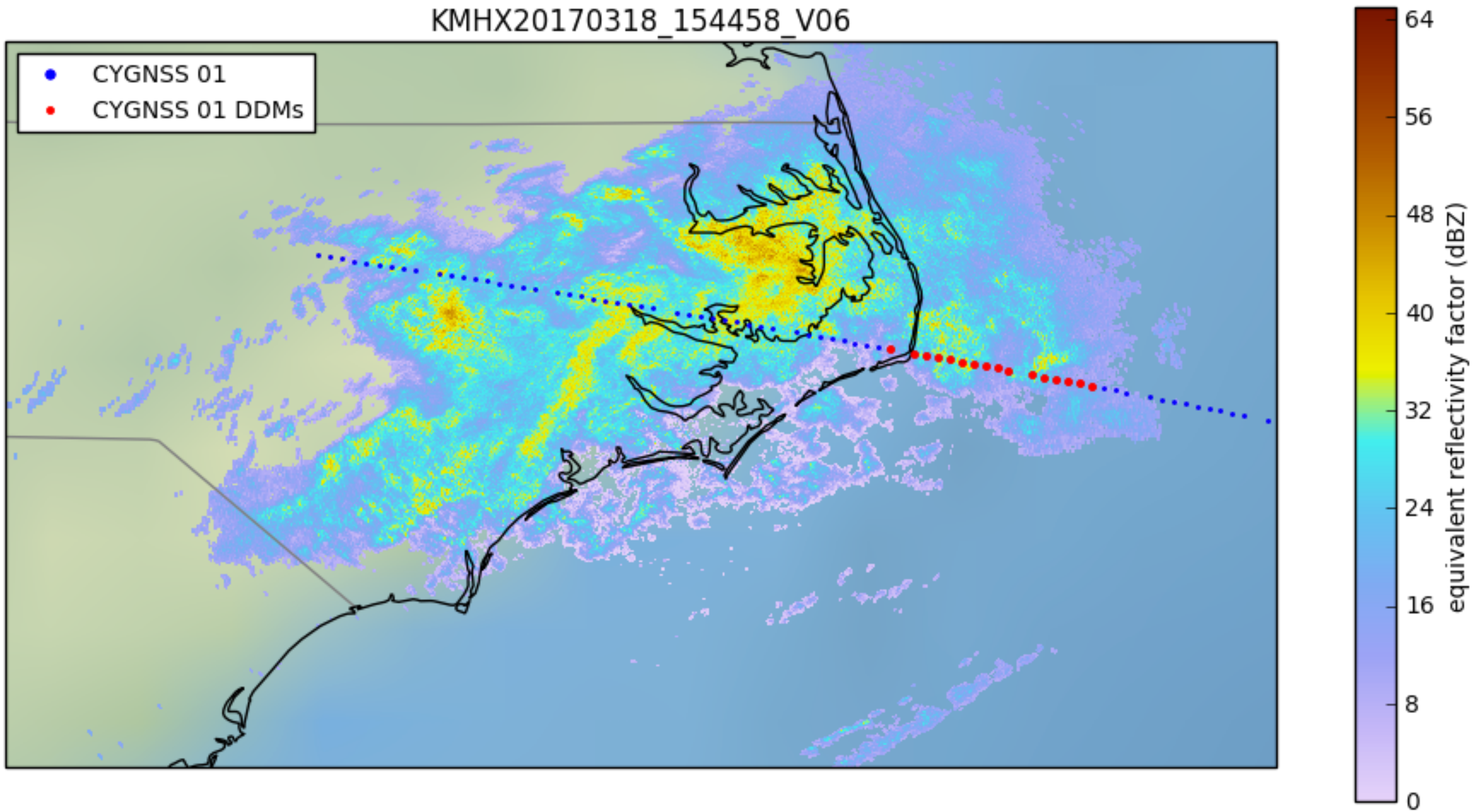
Variable and Forecast	CTRL-NAT RMSE	DA-NAT RMSE
10-m Wind Speed (m/s) @ 11/26, 05 UTC (0-h)	4.9	2.4
10-m Wind Speed (m/s) @ 11/28, 05 UTC (0-h)	4.6	2.0
10-m Wind Speed (m/s) @ 11/28, 15 UTC (10-h)	2.4	2.3
6-h Rainfall (mm) @ 11/28, 18 UTC (13-h)	10.8	9.5

Working With Real CYGNSS Data

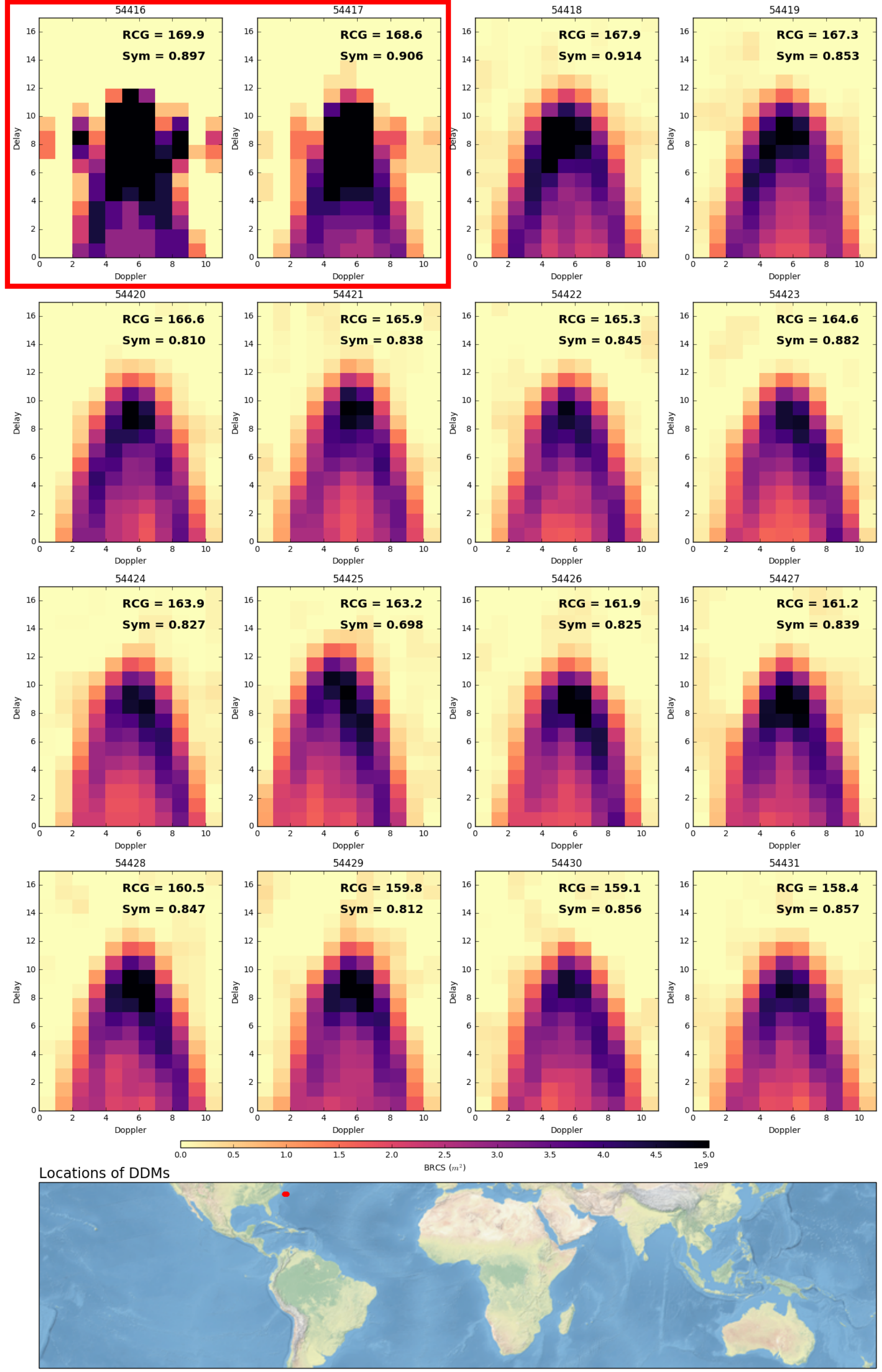


03/18/2017 12:00-16:00 UTC

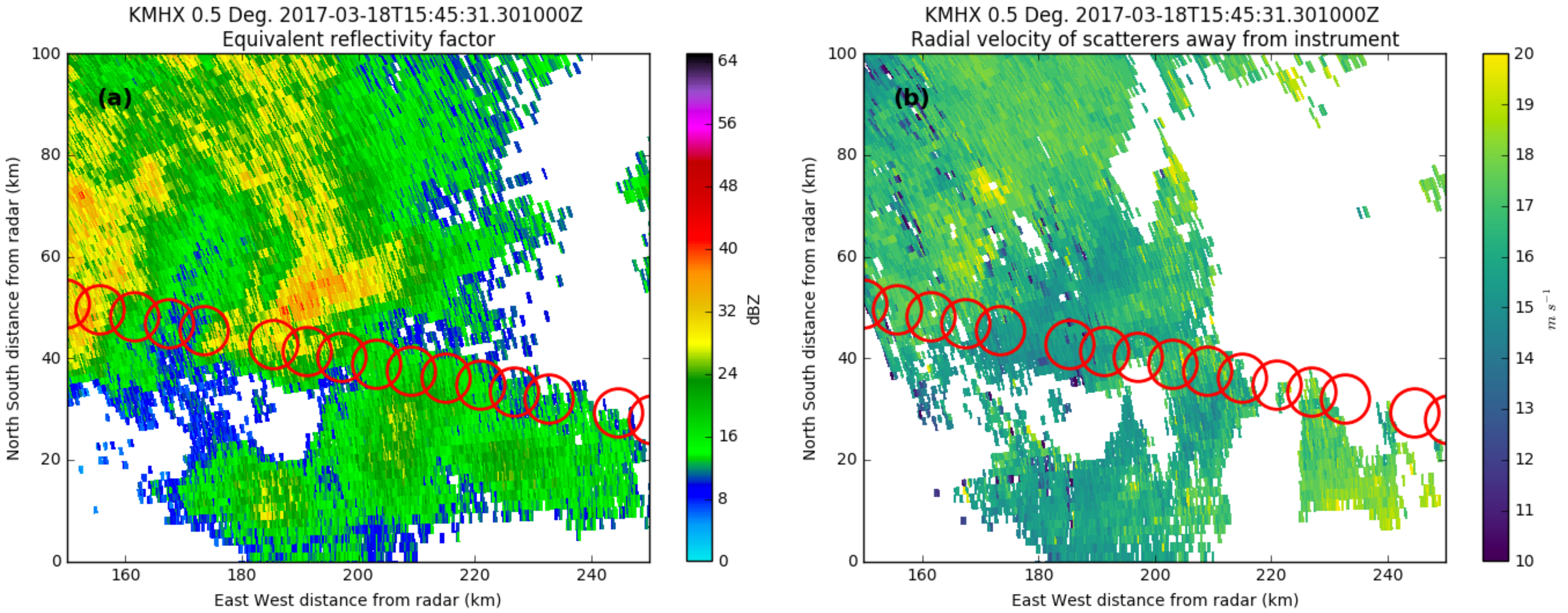



KMHX20170318_154458_V06
CYGNSS 01
CYGNSS 01 DDMs
64
56
48
40
32
24
16
8
0
equivalent reflectivity factor (dBZ)

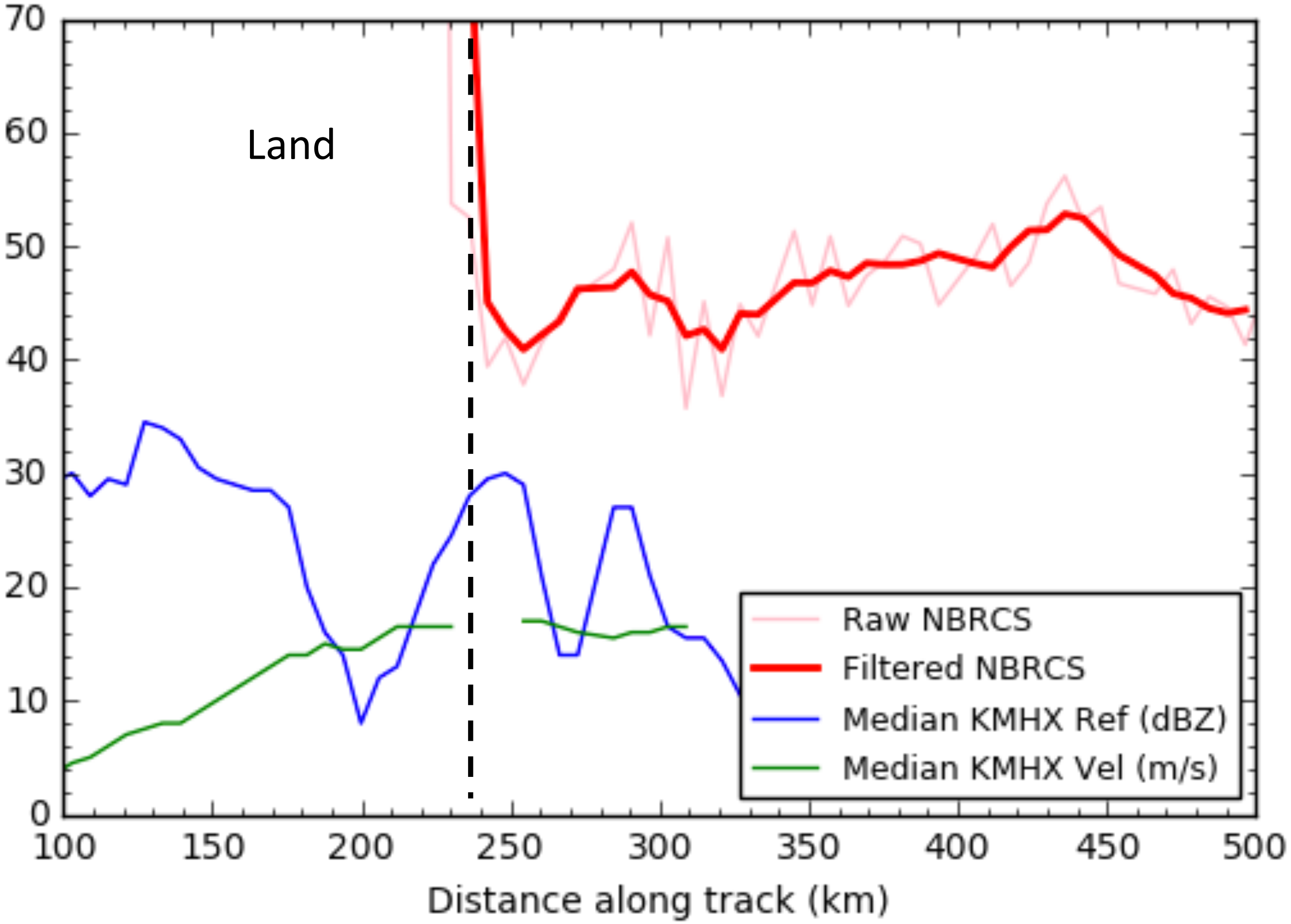
Outer Banks


54416
RCG = 169.9
Sym = 0.897
54417
RCG = 168.6
Sym = 0.906
54418
RCG = 167.9
Sym = 0.914
54419
RCG = 167.3
Sym = 0.853
54420
RCG = 166.6
Sym = 0.810
54421
RCG = 165.9
Sym = 0.838
54422
RCG = 165.3
Sym = 0.845
54423
RCG = 164.6
Sym = 0.882
54424
RCG = 163.9
Sym = 0.827
54425
RCG = 163.2
Sym = 0.698
54426
RCG = 161.9
Sym = 0.825
54427
RCG = 161.2
Sym = 0.839
54428
RCG = 160.5
Sym = 0.847
54429
RCG = 159.8
Sym = 0.812
54430
RCG = 159.1
Sym = 0.856
54431
RCG = 158.4
Sym = 0.857
Delay
Doppler
BRCS (m^2)
1e9
Locations of DDMs

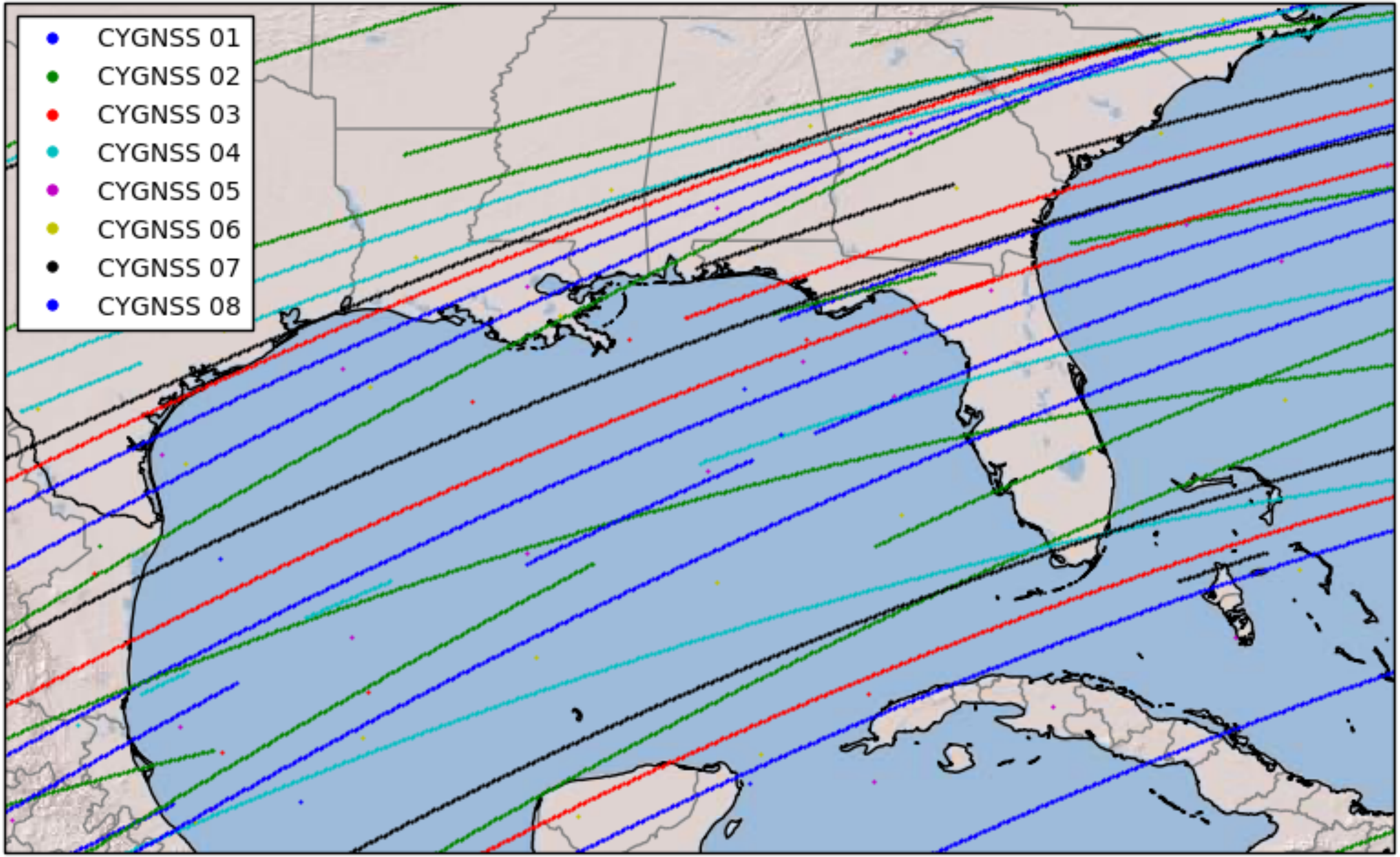
- Light-to-Moderate Precipitation with Variable Doppler winds



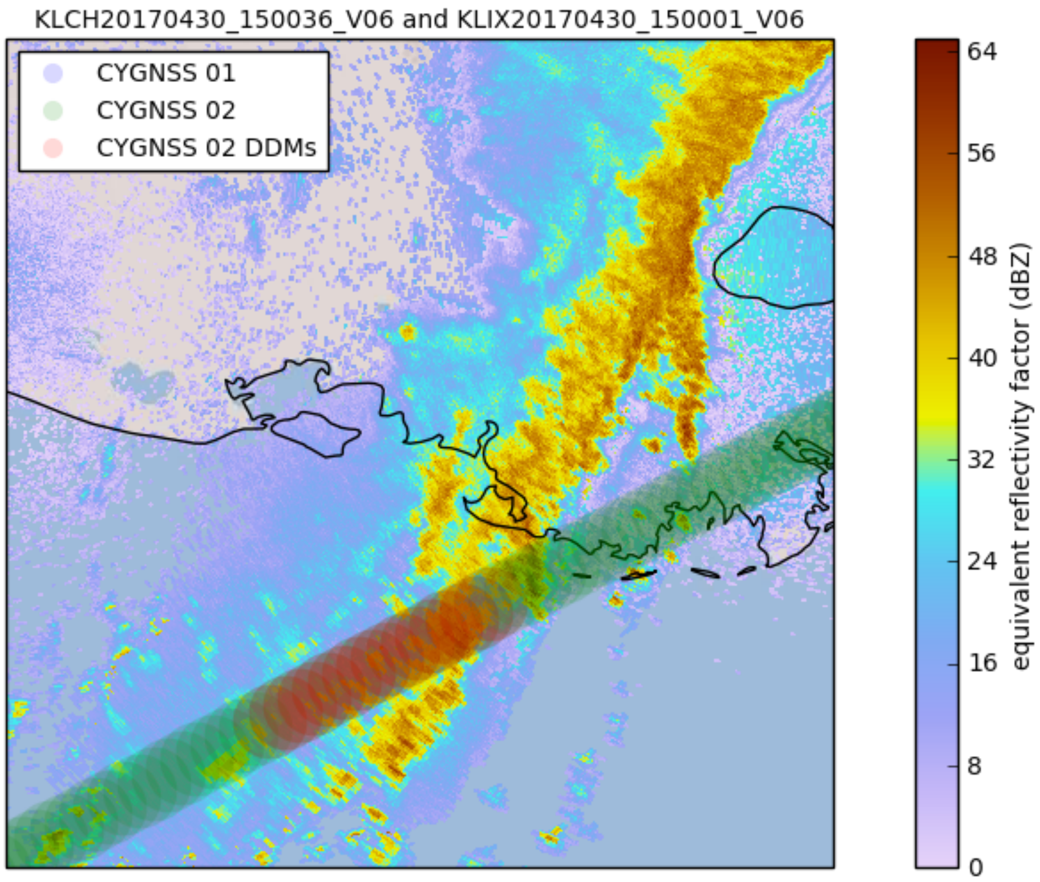
- Along-track ”cross-section” illustrates noise impacts, benefits of filtering
- Reduced NBRCS in offshore echo, suggesting increased winds near precipitation
- Slight decrease in Doppler winds associated with NBRCS increase
- Land signal mixed in toward beginning of time series

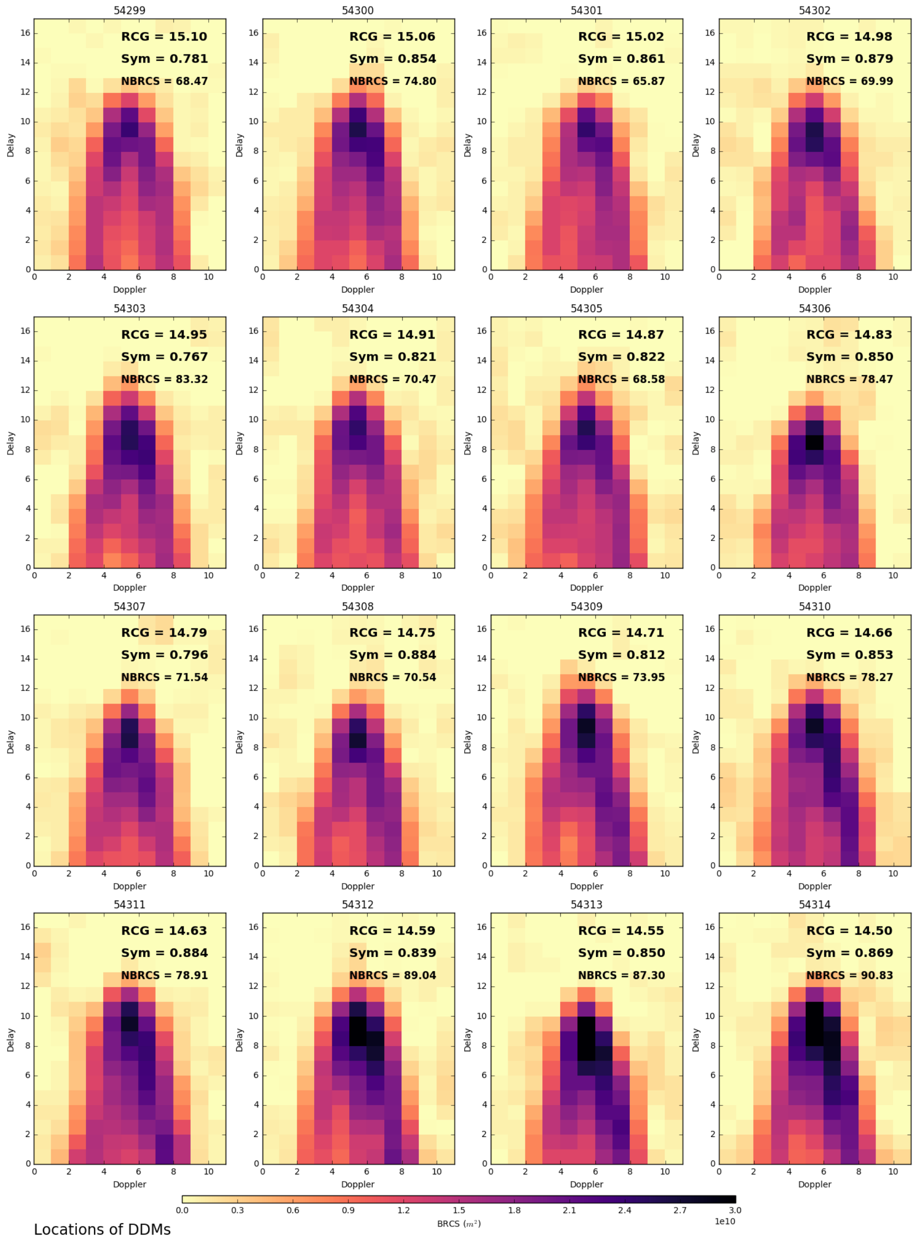


04/30/2017 15:00-17:00 UTC



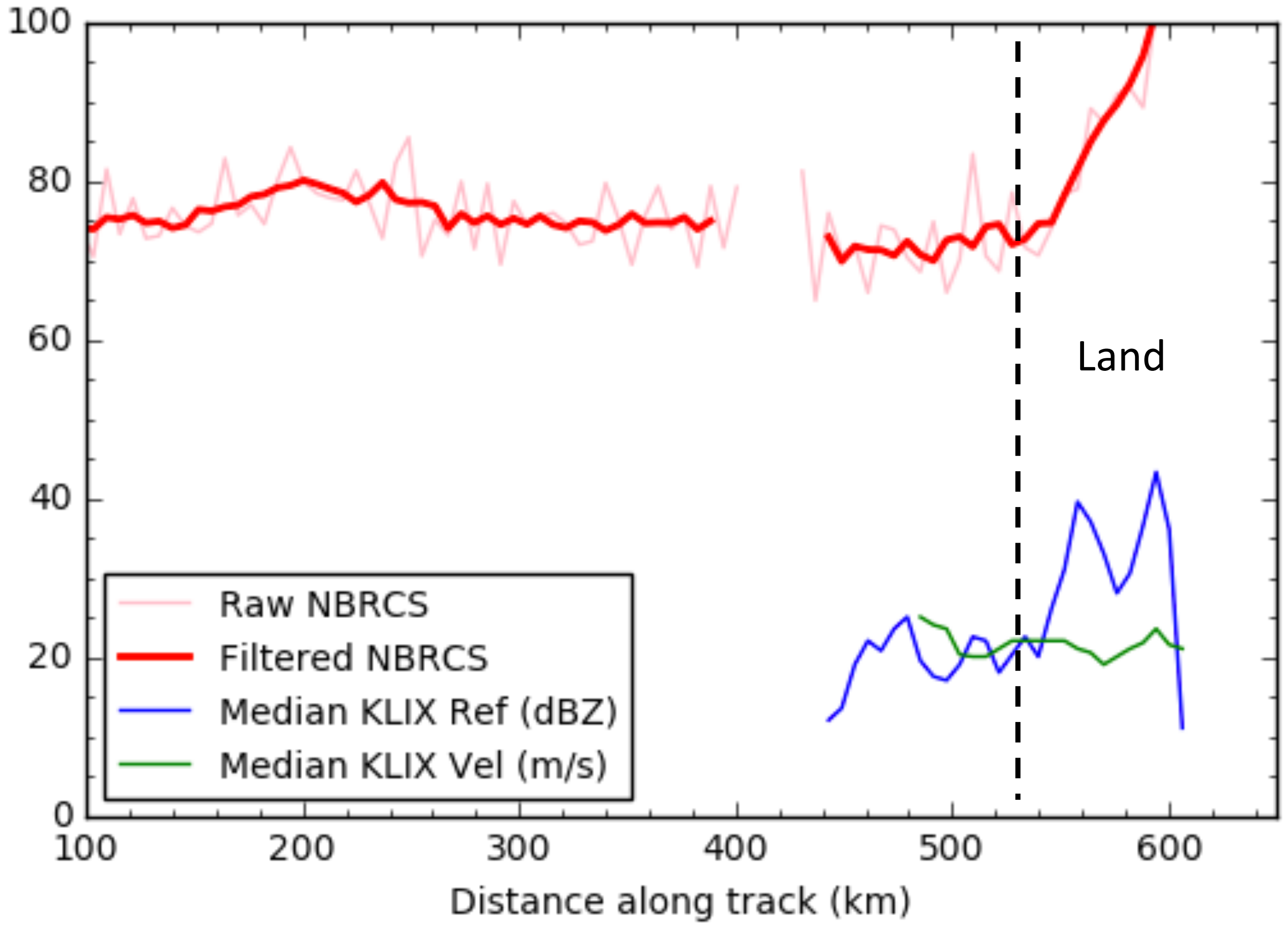
4/30/2017 – Convective line offshore near Louisiana





Locations of DDMs

- Along-track ”cross-section” illustrates noise impacts, benefits of filtering
- Reduced NBRCS in echo, suggesting increased winds in convective line
- Land signal mixed in toward end of times series



Conclusions

- Spatial continuity of individual tracks of CYGNSS specular points provides unique opportunities to examine convectively driven wind variability in all-weather conditions
- Will leverage existing heritage in surface flux estimates to help improve planned CYGNSS sea flux products
- Plans for assimilating CYGNSS data to help improve simulations of tropical convection
- Initial look at real L1 data supports inferences made from E2ES – along-track “cross-sections” show promise for examining tropical convection